

*TWO FRENCH SAVANTS : CHARLES-EUGÈNE BERTRAND,
THE BOTANIST AND PAUL BERTRAND, THE PALEO-BOTANIST.*

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The progress of Botany in the last century is largely a history of tall personalities in plant sciences, who greatly enriched our knowledge of plants, not only in their own countries, but added materially to the progress and revival of Botany elsewhere. The botanical studies in post-Linnaean period till nearly 1850 consisted mainly of studies on plant taxonomy and morphology. The Industrial Revolution towards the end of the eighteenth century and in the early part of the nineteenth century in England and elsewhere ushered in a new area of scientific discoveries in Europe, and colonial rule in other parts of the world. This made it almost imperative for the then major powers like England, France, Germany, Spain, Portugal, Holland and Belgium to study intensively the plants of their colonies with which their economy was linked up due to the advent of the age of machines. This gave a great fillip to the publication of floras of different countries, many of which were published in the first half of the last century. The interest in Botany was naturally confined to systematic botany, economic uses of plants and their utilisation for the purposes of industries.

By the middle of the 19th century, however, two epoch-making works appeared which completely changed the outlook on Botany : 1. « *The Higher Cryptogamia* » by HOFMEISTER (1849-51) and 2. « *The Origin of Species* » by Charles DARWIN (1859). These two works, coupled with the work that was being done by PASTEUR and KOCH on microorganisms reoriented the interests of scientists in the direction of phylogeny, life-histories, cell-structure, anatomy, physiology, pathology, and the past history of plants. A series of workers dealing with these aspects dotted the laboratories all over Europe. In England, the outstanding personalities of this period even after the publication of *The Origin of Species* were Lord BALFOUR, THISTLETON-DWYER, BABINGTON, BENTHAM and HOOKER. In Germany, the revival was more subdued and was directed towards the other aspects of Botany such as cytology, physiology, reproduction in fungi and lower organisms, mainly due to the influence of HOFMEISTER and his school. An ardent follower of this school was Julius SACHS who was to HOFMEISTER what T. H. HUXLEY

was to DARWIN. He and other great Hofmeisterians like DE BARY and GÖBEL were the chief source of inspiration to young workers in experimental botany in Europe. The young botanists in Cambridge and other places also looked to Germany for the study of new developments and technique in practical botany. The French workers at the same time were making a mark by applying themselves to the study of similar problems. For example, the work of THURET, BORNET and RIOCREUX on marine algae and fertilisation therein was as illuminating in understanding the life cycle of these plants as was HOFMEISTER'S work on higher cryptogams. The tradition of DE CANDOLLE and BRONGNIART had by now passed into the hands of PAYEN, BOUSSINGAULT and DE SAUSSURE. In the midst of this hectic activity in the other branches of Botany, Paleobotany was rather a young branch and was attracting only a few but devoted workers. DARWIN'S frequent references to it in the *Origin of Species* and series of excellent monographs on the then little-known plants of the coal measures published by WILLIAMSON in England and RENAULT in Paris developed a small but influential school dealing with the study of ancient plants which included among others classical names such as GÖEPPERT, GRAND'EURY, SCOTT, SEWARD, etc. Both RENAULT and WILLIAMSON exercised a profound influence on the development of the science of Paleobotany. They were associated with many promising young workers amongst whom the name of C. Eug. BERTRAND, in North France, was very prominent. Charles-Eugène BERTRAND, and his son Paul BERTRAND, form a unique pair in the history of Botany in France. They practically ruled the subject of plant Anatomy, Morphology and Paleobotany in France for quite a long time by their ceaseless work and vast influence over a wide circle of disciples and admirers.

Charles-Eugène BERTRAND was born in Paris on 2nd January, 1851, the year in which HOFMEISTER'S classical work on higher cryptogams appeared. He was educated at the University of Paris at the hands of the celebrated systematists of his time like VULPIAN, NORMAND, DECAISNE. Under the influence of these great masters he did excellent work. He was good in mathematics and had a gift of mechanical skill like SACHS; yet he had a passion for the study of natural sciences. A turning point came in his life when in early February, 1871, he had an audience with DECAISNE who asked him to work on some fossil specimens that had come to his hands from diluvial deposits of Seine in 1868. They were collected by DENÉRAIN and given over to DECAISNE who gave them for studying to young BERTRAND. BERTRAND continued his work on them at the Paris Museum, and also his further studies at the University of Sorbonne as an Assistant in the Laboratory of DUCHARTRE. Here he made intensive studies on the

comparative anatomy of the *Gnetales*, *Coniferales* and *Lycopodiales*. These were published as monographs and even to-day evoke admiration for thoroughness and accuracy. On 1878, Ch.-Eug. BERTRAND completed his higher studies at Sorbonne to take the chair in Botany created in the University at Lille to which he was appointed. Here he remained number of years, till his last.

He has expressed his general ideas in his « *Théorie de faisceau* » and his « *Définitions des membres des plantes vasculaires* ». He built a devoted school of workers in the science of Botany. Some of his students were F. MORVILLEZ at Lille M. HOVELACQUE, E. LIGNIER who became professor at the University of Caen, DEBRAY at Alger, A. GRAVIS in Belgium, QUEVA at Dijon... and his son Paul who carried on his scientific work.

As his work progressed large collections accumulated and a series of publications called « *Archives Botaniques du Nord de la France* » were brought out embodying the work done by him and his colleagues, till 1914, when the war broke out.

On 1876, Ch.-Eug. BERTRAND was married to Mlle. Marie HUGONIN, who was at the end of her studies at the University of Sorbonne. Had discovered in her an exceptional accomplishment of mind and heart. Mrs. BERTRAND was very keen on the scientific works to which her husband was so devoted. They had four children, three daughters and a son who later on became the distinguished scholar, Professor Paul BERTRAND. With the starting of the hostilities in 1914, between Germany and the Allies, the town of Lille was invaded by the Germans. Professor Ch.-Eug. BERTRAND refused to leave Lille. He was allowed to do his professorial duties. He rather decided to suffer courageously physical troubles and mental tortures.

In spite of numerous difficulties he had to face due to hostilities, he never thought of deserting his laboratory or discontinuing his teaching or research work. Despite numerous sufferings, he kept up cool and dignified face, which on first impression always made others think him to be a rigid man. His broad forehead and large beautiful eyes belied the warm human heart he possessed. Generally he would exchange only a few words; but in point of courtesies he would never fail. For example, as F. MORVILLEZ (1918) points out, he always used to write without fail to the parents or relatives of his deceased pupils or colleagues on the day of their death anniversary. In 1916, there was bombing near the building of the University, he took then his pupils in his home and pursued their works, even during his last illness. A few days before death he went on with the correction of the examination of the Certificat d'Études physiques, chimiques et naturelles. He died on the 13-8-1917. None of his relatives were allowed to see him; and even the town

of Lille knew about his death only when the funeral notice appeared in a local paper. The city of Lille, the University and the botanists in France, Belgium and England felt a deep agony at such tragic death of this great savant who fell a victim to the cause of Botany and truth, dying at his post.

Professor Ch.-Eng. BERTRAND has made numerous gifts to the science and the University of Lille. The well-known coal Museum at that town is an outstanding monument to his industry and research. But his greatest gift to Botany has been his son Paul BERTRAND, who was destined to make such a profound impression on the botanical world in France and abroad for nearly half a century. It is difficult to find such a strong sense of duty, loyalty to truth, honesty of purpose and dignified behaviour as Professor Charles-Eugène BERTRAND had.

Professor BERTRAND's principal contributions to science, numbering about 115, date as far back as 1868. They continued to appear till 1914 when the war made it impossible for him to publish any more. His excellent manual skill in technical matters, clear thinking of a mathematician and wide vision like that of DARWIN, BRONGNIART and RENAULT made him an exceptionally tall figure in French Botany. He was an extraordinary student of plant anatomy and a keen research worker on vascular cryptogams. His anatomical researches deal with the comparative anatomy of the *Gnetales*, *Coniferales*, *Cordaitales*, Ferns and their allies. His early papers deal with the structure of *Tmesipteris* and *Psilotum* and others deal with the anatomy of *Lycopodium*, *Selaginella* and *Isoetes*. He has made an interesting comparison of the last genus with the *Lepidodendrales*, the knowledge of which was then quite new. By far his most monumental work is on the *anatomy of ferns* in which he has made an exhaustive survey of the anatomical structures present in different parts of ferns. In collaboration with CORNAILLE he surveyed all the possible types of stelar structure met with in the rachis of ferns, and recognised five different types of foliar traces in them. From this he concluded as to the diagnostic value of the different anatomical characters which could be used for recognising the rhizome, petiole and sporophylls in ferns. Though pre-eminently an anatomist dealing with living plants, he threw a good deal of light on the structure of the axis in *Zygopteris*, *Botryopteris*, *Anachropteris* and *Tubicaulis* and showed that the structure of these axes in early ferns is not comparable with those in living ferns. It was he who firmly established the importance of anatomical method in interpreting the morphology of the spore-producing parts of ferns, conifers and cycads. Sometimes this would easily upset some well known notions based on otherwise good grounds. For example, the great controversy between BOWER and CHRYSLER regarding the

foliar or cauline nature of the spike of the Ophioglossales was finally decided in favour of the foliar theory by the anatomical evidence furnished by CHRYSLER on the lines of BERTRAND and CORNAILLE. In this paper, CHRYSLER (1910) has compared the anatomy of the spike of the *Ophioglossaceae*, among other things, with the anatomy of the sorophores of the *Schizaeaceae*, e. g. *Anaemia* which has leaf traces similar to those in the spike of *Ophioglossum*.

Professor BOWER's work on the Phylogeny of Filicales and Professor OGURA's work on the anatomy of the vegetative parts of the Pteridophytes is replete with references to the works of Ch.-Eug. BERTRAND and his associates, which is no small testimony to his great work and its utility in interpreting problems of fern morphology and anatomy. Ch.-Eug. BERTRAND in his early works was also associated with well known paleobotanists of his time like B. RENAULT on account of which he got interested in the study of coal and peat.

He started his studies on *bogheads* and showed that they contain fossilised micro-organisms like *Reinschia* and other algae forming water blooms. They secrete a sort of jelly which becomes carbonised. This line of work yielded wonderful results regarding the nature and structure of coal and coal balls at the hands of his son Paul BERTRAND and Zalessky later.

It is a pity that such a devoted scientist should have died under such trying conditions of life in a manner so tragic as to move the conscience of botanists all the world over. The French nation has, however, always honoured Ch.-Eug. BERTRAND. He was made Chevalier de la Légion d'honneur, in 1903 and also Chevalier de l'Ordre de Léopold of Belgium in the same year (1903), Membre Correspondant de l'Institut de France in 1904. The University of Geneva confirmed the Honorary degree of D. Sc. on him in 1909. The war deprived him of further glories towards which he was heading. His death was lamented by a large circle of eminent botanists in France, Belgium, England, America, etc.

Ch.-Eug. BERTRAND died in full scientific activity, leaving many important works and ever lasting model of a Master, a scrupulous and courageous savant and a of high moral personality.

Paul BERTRAND.

Paul BERTRAND was born on 10th July 1879 at Loos-les-Lille. After his early education, he studied for his Licenciata's degree in Sciences under renowned masters in Geology, and Botany like Jules GOSSELET of stelar's theory's fame and Charles BARROIS, his

father, the great anatomist; and in Chemistry under Richard FOSSE, his colleague later at the Museum.

Thus, by his education, personal aptitude and family tradition, he was highly suitable for studies in Science.

Early in 1906, his name was entered on the list of University as Laboratory Assistant in the Coal Museum of Lille. This Museum, in the vicinity of rich mining areas of Alsace and Lorraine, Saar, Belgium is a standing monument to the life and work of two BERTRAND. It was here that Paul BERTRAND worked on his early papers dealing with the structure of *Adelophyton Jutieri*, *Ankyropteris* and *Stauropteris* (1907). He got a degree of Doctor of Science, in 1909, with a remarkable thesis on « The Anatomy of Ancient Ferns », « *les Zygoptéridées* » and was appointed to lectureship the year after, and was entrusted with the course in Palaeontology. His Thesis, *Etudes sur la fronde des Zygoptéridées* roused much interest among French and foreign specialists. It was soon followed by other monographs upon other forms of primitive plants, such as the *Cladoxylées* and by a remarkable restatement of the question concerning the Anatomy of ancient ferns, published in Germany in the *Progressus Rei Botanicae* (1912).

At the age of thirty Paul BERTRAND was ranked as one of the authorities on the anatomy of the ancient cryptogams. Later on, in 1929, he resumed the studies on the algae of the bogheads that had been previously described by his Father and B. RENAULT.

Acknowledging his efforts and repute, the Faculty of Sciences of Lille founded for him an Academical chair in Paleobotany-in 1927, a chair he made famous, and round father gathered brilliant students : G. LIVET, G. DUBOIS, G. MATHIEU, P. DELEAU, W. C. DARRAH, P. CORSIN etc...

Paul BERTRAND was also the first collaborator of his master Charles BARROIS in geology. For more than twenty years him alone, or with other geologists, such as Pierre TERMIER, Georges FRIEDEL, Pierre PRUVOST, as he explored the working of the French collieries.

Paul BERTRAND studied not only the coal-measures of the North and Pas-de-Calais, but also those of Saint-Étienne and Lower Dauphiné, the Gard Basin, all of the large coal-seam of the Massif Central, those of the Saar and Lorraine, of the Alps, of Algeria, of Marocco, of Pensylvania (U.S.A.), etc...

This analytical research resulted in the drawing up of a *stratigraphic scale of all coal-fields of Western-Europe*, making them more explicit than that of his predecessor R. ZEILLER, and he wrote magnificent volumes on the *flora of the Saar and Lorraine Basins*.

The French Government decorated him with the Order of the Legion of Honour in 1933.

Paul BERTRAND was a dignitary of many societies of scientists, and his fame was well established in the scientific world by the honour foreign colleagues gave him very often. In 1938, the vote of his peers called him to the National Natural History Museum, in Paris to hold the Chair of Comparative Anatomy of Living and fossilized plants. This he occupied with great dignity and earned a name as a scientist all over the world, falling thereby at once in line with the great French masters like A. BRONGNIART, de SAPORTA, C. GRAND'EURY, R. ZEILLER.

Due to his good manners, winsome personality, and friendly qualities, most of the foreign botanists such as BOWER, SCOTT, SEWARD, NATHORST, HALLE, POTONIÉ, SAHNI, etc., used to look upon him as their personal friend.

A number of research papers appeared dealing with the structure and contents of coal and bogheads. By far the most remarkable work he brought out was his special studies on *Cladoxylales*, a very highly specialized, simple yet controversial group, similar to *Zygopteridinae*.

As a matter of fact, much of our knowledge of it we owe to him and also our understanding the organization of the *Zygopteridinae*. The idea of Phyllophore is a striking addition to Morphology.

The language of his papers and discussions is simple and direct. It gives precise details on which he used to build the structure of his theories. His essays on Morphogenesis, History of theories on plant morphology, the three aspects of the theory of recapitulation, Phylogeny of vascular plants, a new classification of the *Zygopteridinae* are classical in tone and presentation and direct in appeal. Many of these papers have been brought together, by his distinguished consort, Mme. Paul BERTRAND, in the form of a posthumous publication originally planned by him : « Les Végétaux Vasculaires », *Introduction à l'étude de l'Anatomie Comparée*, which he had decided to write (1947). This publication was awarded the Prize Guido-Triossi by l'Académie des Sciences de Paris (1947), in order to honour the memory of Paul BERTRAND. It is rather interesting that it has been possible to issue this volume even if incomplete.

By his death a grand figure like that of BOWER in British botanists, or like that of BRONGNIART, RENAULT and Ch.-Eug. BERTRAND in the French school, or SAHNI, in the Indian school of botanists disappeared. It clearly marked the end of a classical era in Paleobotany, the height of which marks also the zenith of the careers of its votaries, like A. C. SEWARD, P. BERTRAND and B. SAHNI. In these days when every now and then an emphasis is laid on applied aspects of botany due to current influences, the importance of continuing researches on the structure and anatomy

of living and fossil plants dealing with the fundamental aspects of botany needs to be restated. The researches in fundamental botany are like a well which feeds water to individual problems running on diverse lines.

Fundamental researches like those in paleobotany are important not only in themselves but also as a matter of very important discipline. The science of Paleobotany, already impoverished by the death of its stalwarts like SCOTT, SEWARD, BERTRAND and SAHNI, emphasises a method of synthesis, comprehensive thought, vision, accuracy of observation, that few other disciplines in Botany can afford. The writings like those of SCOTT, BERTRAND, SEWARD and SAHNI are even to-day a source of inspiration to research workers, as much as those in any other branches of Botany; and hence the universities would do well by re-enforcing the studies on Paleobotany and comparative anatomy of living and fossil plants by making these subjects obligatory for all post-graduate degrees.

The works of P. BERTRAND are much varied and numerous, the total number of principal publications being 150. It will not be possible to assess the whole of his work within this short note, but it may be briefly summarised as follows:—

1. Analysis of fundamental ideas regarding the origin of vascular plants and their phylogeny.

2. Studies on the Cladoxylales, Zygopteridinae, Pteridosperms and other members of the Carboniferous period.

3. Studies on the comparative anatomy of living and fossil plants and their bearing on the interpretation of structures met with in the fossil plants. Having inherited from his father, the tradition of studies on Fern anatomy Paul BERTRAND was always at ease and at his best when dealing with the comparative anatomy and morphology of the living plants in comparison to fossil ferns.

4. Vegetation and plants of the coal measures and bogheads. Here he identified a number of micro-fossils met with in the coal balls, oil-shales, peat, and coal, and thus laid the foundation of a new branch of Paleobotany, the study of micro-fossils, so zealously followed by workers all the world over such as SCHÖPE, ERDTMANN, COOKSON, SITHOLEY, PANT and others. He identified a large number of genera in the peat and in the bogheads, many of which are similar to the living genus *Botryococcus*.

A detailed review of the work done either by him or in collaboration with other students such as CORSIN, BOUREAU, EMBERGER and others has been given by EMBERGER (1944). His classification of the *Zygopteridinae* into two groups such as Phyllophorales and the non-phylophorales has received almost universal acceptance. Equally brilliant are his researches on the coal measure plants,

algae of the bogheads and their stratigraphy. Paul BERTRAND's success as a paleobotanist lies in the fact that he had a great mastery over the anatomy of living plants which enabled him to give examples to illuminate the anatomy of the latter or to interpret some knotty points in their structure. For example, he has compared the structure in the petiole of *Clepsydropsis* with the foliar traces of the *Hymenophyllaceae* and *Gleicheniaceae* and *Osmundaceae*, or the petiolar bundle of *Anachoropteris* and *Botryopteris* with that of *Osmunda regalis*, *Ceratozamia mexicana* and *Pteris aquilina*. His interpretation of the mode of formation of coal is well accepted. It is a pity that when Professor P. BERTRAND was at the height of his mental processes and was in a position to pronounce on many doubtful points regarding the origin and evolution of vascular plants, he should have been snatched away by the cruel hands of death. There is indeed something very tragic about the death of both the father and the son.

P. BERTRAND had a rare gift of friendship which was valued by all his botanists and non-botanists friends.

When he died, a large number of tributes were paid to him by men no less than BLARINGHEM, PRUVOST, BOWER, WALTON, SAHNI, FLORIN, HARRIS, EDWARDS, HALLE, HOCHREUTNER, NEMEJC, DARRAIL, etc... which testifies to the great authority and popularity which he enjoyed throughout his life; and by these who belong to different fields of science. They have expressed their regrets in these words: « Paul Bertrand seems to be irreplaceable, his discoveries are not only for Botany, but they struck all naturalists » (Ch. PÉREZ, J. BECQUEREL, L. FAGE, J. MAGROU, etc.).

It is difficult to come across a man who could at once be accepted as an authority and yet a highly popular figure as BERTRAND was. For a number of years to come Paul BERTRAND's name will be remembered as the chief architect expounding the structure of vascular plants by the method of comparative anatomy. To Ch.-Eug. BERTRAND comparative anatomy of fossil plants illustrated numerous experiments and failures of nature in the evolution of morphological or anatomical patterns. Paul BERTRAND thought that these patterns represent the landmarks in the formation of organs and morphogenesis of vascular plants which ultimately dominated the land. Without proper understanding of fossil plants much of our knowledge of vascular plants would have been mere theorising, and concepts such as metamorphosis, morphogenesis and law of recapitulation would have become meaningless.

By painstaking researches and careful interpretations Paul BERTRAND has added much to our understanding of the structure and phylogeny of the vascular plants of which he could have been legitimately proud; and yet it was characteristic of him to be

simple. A brilliant summary of the anatomical methods and how he progressed to develop them are given by him in his inaugural lecture at the National Natural History Museum of Paris on 12th June, 1941. Here he has traced practically the whole history of paleobotany and its development in France. For nearly hundred years he and his father played no small part in its development; and yet in the end he concludes this address by referring to the importance of the collections in the museum by saying « they are a scientific and moral heritage fortunately left to us. » He further says, that eventually their study will lead us to a point of departure in another direction of progress and will land us in entirely new lines of enquiry. It is quite obvious that he was fully alive to the new possibilities of morphogenesis and mutations in plants which would largely decide the progress of morphological studies in years to come. This is really a grand prelude to the modern trends in Botany. More so as, it comes from a worker who devoted all his life to the study of fossil plants, which reveal both the magnitude of Nature's experiments and her failures in experimental morphology. In these days of atomic researches, study of cytology, nuclear behaviour, chemical changes associated with it, hormones and morphogenesis will no doubt play more and more important part in botanical sciences and yet the study of ancient plants is really of fundamental importance as its votaries have always claimed. There could be no two opinions about this. If anything, it needs a reiteration for the progress of the human mind and research.

It is my good fortune to be associated with this line of work for which I drew no small inspiration from these two illustrious savants of France and from my teacher, the late Professor SAHNI, who also was a great admirer of both; and I close this note expressing my gratitude to Mme. Paul BERTRAND, and to the authorities of the National Natural History Museum of Paris for giving me this opportunity to pay my homage to the memory of these two departed botanists of France, Ch.-Eug. BERTRAND, the father and Paul BERTRAND, the son.

May 1st, 1954, Department of Botany, University of Poona, India.